

AN ANNOTATED CHECKLIST OF THE FISHES OF THE SWAN-AVON RIVER SYSTEM, WESTERN AUSTRALIA

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ABSTRACT

The checklist of the fishes of the Swan-Avon River System in south-western Australia given in this paper is based on the collections and records held by the Western Australian Museum, and on the results of a recent extensive sampling programme carried out with beach seines, trawls and mesh nets. The latter study has also provided data on the distribution of many of the species within the river system. The 110 species recorded are predominantly of marine origin and can be regarded either as marine "stragglers," or as fish which utilize the estuary predominantly as a nursery area or adult feeding ground, or as an environment that can be exploited at various times during the life cycle. Several of the most abundant species are, however, represented by populations that can pass through the whole of their life cycle within the Swan-Avon River system. Although, as with other south-western Australian rivers, the indigenous freshwater fish component is highly impoverished, its abundance in this system has also suffered from the effects of damming, periods of "drying-up," eutrophication and run-off from agricultural land. At the same time, some of the changes brought about by damming have produced conditions favourable for the establishment of populations of certain introduced species. Comparisons between the fish fauna of the Swan-Avon River System and the limited data for other Western Australian coastal rivers suggest that Cape Naturaliste represents the approximate southern limit of the distribution of many northern species, while the corresponding point for the northwards extension of several southern species is in the region of the North West Cape.

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INTRODUCTION

The Swan-Avon River System (lat. 32°04', long. 115°44') is defined by Jutson (1934) as comprising three rivers and their tributaries, namely the Swan-Avon, Helena and Canning. This river system is by far the most important commercial and recreational river in Western Australia, where it runs through the two principal cities of Perth and Fremantle (Figs 1, 2). During recent years, a number of studies have added to our knowledge of both the invertebrate fauna and the hydrological conditions existing in this river (see Hodgkin and Majer, 1976). By contrast, and despite the presence of a large amateur and viable commercial fishery, there is no comprehensive account of the composition of the fish fauna of the Swan-Avon River System and few publications on the ecology of individual species within this system. An exception to the latter generalisation is provided, however, by Kowarsky's studies (1973, 1975) on the Cobbler, *Cnidoglanis macrocephalus*. Moreover, broad-based ecological data on certain of the predominant and commercially important teleosts found in Western Australian estuaries, such as anchovies (Blackburn, 1950), mullets (Thomson 1950, 1951, 1954, 1955, 1957a, b, c, d, 1966) and whiting (Lenanton, 1970), were based to some extent on animals collected from the Swan-Avon River System. It is worth noting that the only published information on the general biology of many of the fish species found in a single Western Australian river system is that provided by Lenanton (1977a) in his account of the fish fauna of the Blackwood River Estuary.

The main objective of this paper is to provide an annotated checklist of the fish fauna of the Swan-Avon River System, providing details where possible on the distribution of the various species within the estuarine and fresh water components. The data have been compared with the results obtained for other south-western Australian estuaries in an attempt to interpret the distribution of fish in a zoogeographical context. In addition, the information on the biology of the more abundant species is used to provide a series of life cycle categories with respect to the way in which the species utilize the Swan-Avon River System.

DESCRIPTION OF THE SWAN-AVON RIVER SYSTEM

Although the mouth of the Swan Estuary is narrower than might be expected for a river of this size, it is in fact wider and deeper than that of most other estuaries in south-western Australia. This is mainly due to the dredging which has taken place in this region to remove sand sills and a rock bar to widen and deepen the entrance to Fremantle Harbour which constitutes the major Port of Western Australia (Seddon, 1972).

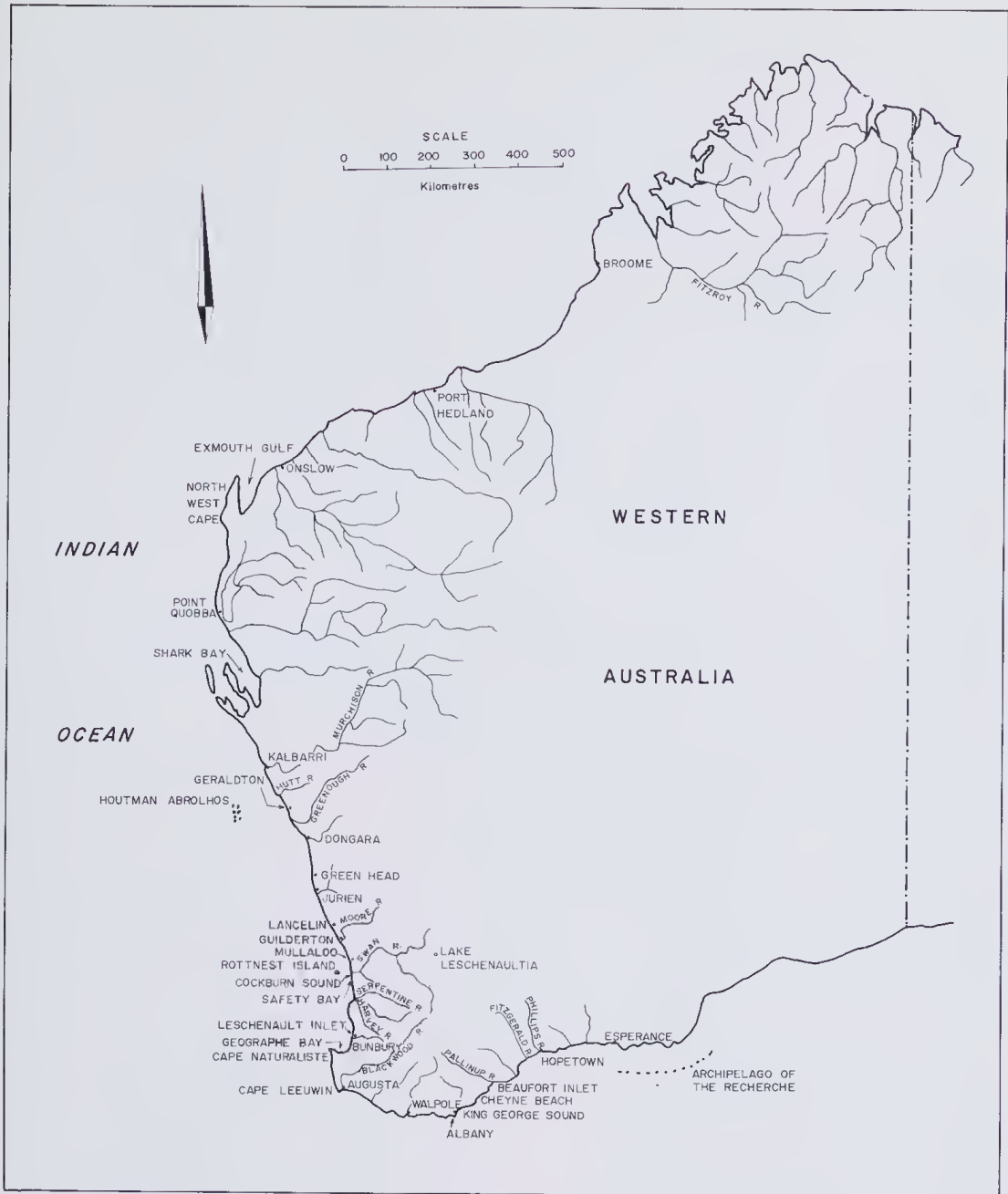


Fig. 1: A map showing the localities and rivers in Western Australia which have been mentioned in the text.

N.B. For convenience the cities of Perth and Fremantle have been omitted but are included in the detailed map of the Swan-Avon River System shown in Figure 2.

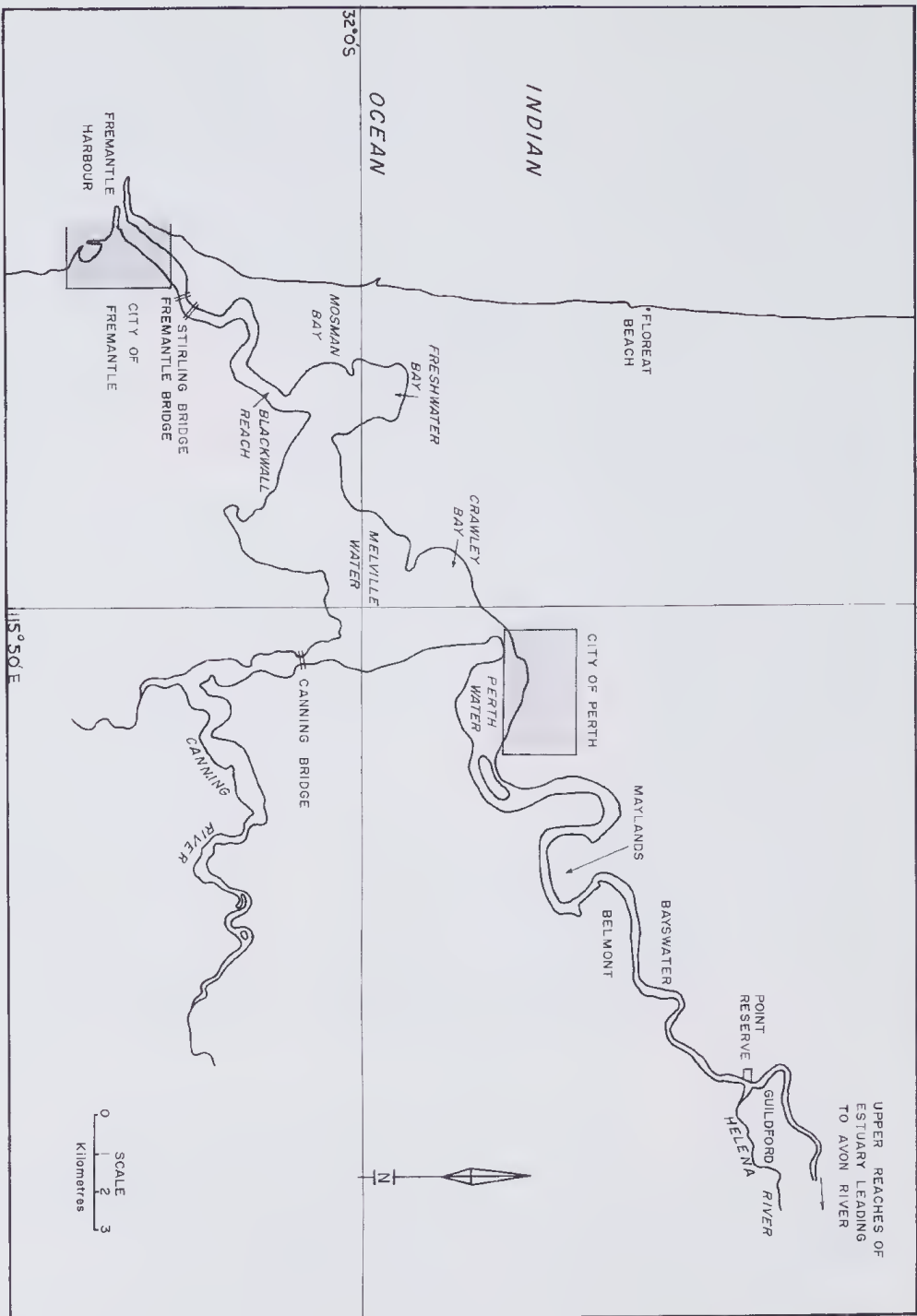


Fig. 2: A map of the Swan-Avon River System.
 N.B. The extensive catchment constituting the upper Swan and Avon River are not included.

The physiographic and hydrological aspects of the Swan Estuary have been described by a number of workers, including Jutson (1934), Rochford (1951), Spencer (1956), Wilson (1964, 1968) and Jack (1977). Recently, Chalmer, Hodgkin and Kendrick (1976) suggested that, as a biotope, the estuary could be appropriately divided into a lower, middle and upper component. Although their definitions of the regions corresponding to lower, middle and upper estuary are followed in this paper, the term lower reaches is also used when, as is often the case, marine species have been found extending through the lower estuary into the bottom end of the middle estuary.

The lower estuary comprises an inlet channel region which meanders through a calcarenite limestone coastal ridge from Fremantle Harbour to, and including, Blackwall Reach (Fig. 2). The wider areas of Mosman and Freshwater Bays and the seaward end of Melville Water, which constitute the beginning of the middle estuary attain depths of 21 m. The increase in the width of the system in this region is developed even further immediately upriver in the main part of the middle estuary where Melville and Perth Waters reach maximum widths of approximately 4 and 1.5 km respectively. These latter two localities are permanently submerged flood plains with the former occasionally reaching depths of approximately 6 m. It should be noted that Chalmer *et al.* (1976) also regards the bottom and middle of the Canning River as belonging respectively to the middle and upper estuary of the Swan-Avon River System. The salinities in the upper estuary in 1977 ranged from maxima of about 30‰ at the lower end to approximately 20‰ near Guildford, which represented our most upstream sampling locality. Although the Canning and Helena Rivers, which have both been dammed for many years, pass through forests and are therefore relatively fresh, the Avon has become saline by receiving run-off from the extensively cleared agricultural land through which it passes (Kendrick, 1976).

In most years, the environmental conditions that prevail in the Swan-Avon River System during the winter differ markedly from those found in other months (Rochford, 1951; Spencer, 1956; Wilson, 1968; Hodgkin, 1974; Bayly, 1975; Jack, 1977). Thus, between approximately May and September, periods of heavy precipitation lead to extremely rapid increases in the volume and rate of freshwater discharge from the catchment tributaries. At these times, the salinity can drop markedly within 24 hours throughout the whole of the estuary and lead to the formation of marked haloclines, particularly in the deeper regions of the middle and lower estuary. During the other months of the year, the level of precipitation is very greatly reduced, a feature which results in little freshwater discharge taking place into the estuarine part of the system.

Since the normal tidal range in the lower reaches of the Swan Estuary, such as at Fremantle, used to be generally only about 50 cm (Bennett, 1940), and is now also still only about 70 cm (Fremantle Port Authority Records), astronomical tidal changes do not markedly affect the movement of water within most of the estuary in the summer months. This feature, together with the limited freshwater discharge, is the major reason why water levels generally change only slowly during this time of the year. The main factor producing water movement in the summer is in fact neither of these two components but the effect of changes in barometric pressure. For example, any sustained periods of high pressure and off-shore winds lead to a movement of water towards the sea which often leaves sand banks exposed for several days (Seddon, 1972). The high relative degree of stability of the estuarine region of the Swan-Avon River System in the warmer months is also reflected by the relatively slow changes that occur in salinities during this period. While the salinity in the middle estuary is maintained at levels just below full strength sea water, some shallow areas such as Alfred Cove (Fig. 2), become slightly hypersaline (c. 36.5‰) through evaporation.

BASIS OF CHECKLIST AND NOTES

Initially, a detailed analysis was made of the fish collections and records accumulated for the Swan-Avon River System since 1912 by the Western Australian Museum (WAM). These data were then supplemented by the results obtained in a comprehensive sampling programme carried out in the Swan Estuary between January 1977 and March 1978 using beach seines, trawls and mesh netting. This latter investigation resulted both in the addition of a few more species to the checklist and in the collection of sufficiently large samples to provide sound basic information on the biology of some of the more abundant species.

The popular names used in the species notes in general follow those given in Scott, Glover and Southcott's (1974) book on South Australian fishes, which is the only appropriate recent authoritative text that covers extensively the fish found in south-western Australian rivers and estuaries. It should be noted, however, that local Western Australian names are also given when they are widely used in this part of Australia. The checklist is arranged in phylogenetic sequence, following in the case of teleosts the scheme proposed by Greenwood *et al.* (1966), except in a few instances where recent studies have suggested the need for minor modification.

In the species accounts, where there were sufficient data on the biology of the fish, the term 'o-group' was used to denote those animals that were clearly in their first year of life. This distinction is of particular significance in the context of estuaries, since they are widely utilised as nursery areas by marine fishes (Cronin & Mansueti, 1971; Pollard, 1976). In contrast with this category are those marine fish which generally use the estuary as a feeding ground only at some stage after the first year of life. The term estuarine is only applied to populations of these species of fishes in the Swan-Avon where there is strong evidence that they can pass through the whole of their life cycle in the estuary. Another category of fish found in the Swan-Avon River System are the fresh-water species which, depending on their osmoregulatory ability, may also occasionally be found in various regions of the estuary.

CHECKLIST

GEOTRIIDAE

GEOTRIA AUSTRALIS GRAY, 1851

Geotria australis Gray, 1851: 142 (Inkapinki River, South Australia).

The Pouched or Wide-mouthed Lamprey is an anadromous parasitic species which undergoes very marked morphological changes during its spawning migration, a feature which in the past has led to a considerable confusion over its taxonomy (Potter & Strahan, 1968). Although this lamprey used to be observed occasionally in the Swan-Avon River System, and the Canning River in particular, there have been few confirmed reports of its presence in this region of Western Australia during the last few years. A recent laboratory study on this species has suggested that this may be related to the fact that its ultimate incipient lethal temperature is similar to temperatures (28-30°C) often now found in the Swan-Avon River System during the summer (Macey & Potter, 1978). It is clear from local reports that this lamprey used to be very abundant in the rivers of south-western Australia but that its numbers have declined in recent years.

Distribution

Tasmania, Victoria, South Australia to Fremantle in Western Australia and also in New Zealand and the southern part of South America.

HETERODONTIDAE

HETERODONTUS PORTUSJACKSONI (MEYER, 1793)

Squalus portusjacksoni Meyer, 1793: 71 (Port Jackson, New South Wales).

Only one specimen of the Port Jackson Shark has been recorded from the Swan-Avon River System, this being collected from the Maylands region of the river during May 1977.

Distribution

Southern half of Australia to the Houtman Abrolhos in Western Australia.

SPHYRNIDAE

SPHYRNA ZYGAENA (LINNAEUS, 1758)

Squalus zygaena Linnaeus, 1758: 234 (Europe and America).

One specimen of this hammerhead shark from Mosman Bay is housed in the WAM collections.

Distribution

Widespread in temperate waters of the world.

CARCHARHINIDAE

CARCHARHINUS LEUCAS (MÜLLER & HENLE, 1841)

Carcharias (Prionodon) leucas Müller & Henle, 1841: 42 (Antilles).

An extraordinary feature of the records for the Swan River Whaler is that this shark has been caught on several occasions in the Swan Estuary but never as yet in the surrounding oceanic regions. Furthermore, specimens have been reported from regions 320 km up the Fitzroy River in the Kimberley region of Western Australia (R. Emiliani, pers. comm.).

Distribution

Worldwide, preferring warmer waters.

RHINOBATIDAE

APTYCHOTREMATA VINCENTIANA (HAACKE, 1885)

Rhinobatus vincentianus Haacke, 1885: 488 and 508 (St. Vincent Gulf, South Australia).

One specimen of the Shovelnose Ray or Guitar Fish from Freshwater Bay is present in WAM collections.

Distribution

South Australia to Fremantle in Western Australia.

MYLIOBATIDAE

MYLIOBATIS AUSTRALIS MACLEAY, 1881

Myliobatis australis Macleay, 1881: 380 (Port Jackson, New South Wales).

One specimen of this species of eagle ray has been collected from Melville Water.

Distribution

Southern half of Australia to Lancelin in Western Australia.

ELOPIDAE

ELOPS MACHNATA (FORSSKÅL, 1775)

Argentina machnata Forsskål, 1775: 68 (Red Sea).

The Giant Herring is a marine species which is caught at regular intervals throughout the Swan Estuary.

Distribution

Indo-West Pacific, preferring warmer waters. In Western Australia, it has been found as far south as Albany.

MURAENIDAE

GYMNOTHORAX WOODWARDI McCULLOCH, 1912

Gymnothorax woodwardi McCulloch, 1912: 80 (Pelsart Island, Houtman Abrolhos, Western Australia).

Woodward's Reef Eel is infrequently collected from the lower reaches of the Swan Estuary as far upriver as Melville Water.

Distribution

Western Australia only, from Albany to the Houtman Abrolhos.

OPHICHTHIDAE

CALAMURAENA CALAMUS (GÜNTHER, 1870)

Ophichthys calamus Günther, 1870: 74 (Fremantle, Western Australia).

The Fringe-lipped Snake Eel is a marine species which has been recorded only once for the Swan Estuary at Freshwater Bay.

Distribution

Western Australia only, from Geographe Bay to Exmouth Gulf.

OPHISURUS SERPENS (LINNAEUS, 1758)

Muraena serpens Linnaeus, 1758: 244 (southern European seas).

The Serpent Eel is a marine species which is frequently collected from as far upriver as Canning Bridge.

Distribution

Mediterranean, South Africa, Japan, New Zealand and temperate waters of Australia.

CLUPEIDAE

AMBLYGASTER POSTERA WHITLEY, 1931

Amblygaster postera Whitley, 1931: 144 (Fremantle, Western Australia).

The Scaly Mackerel is a marine species found toward the lower end of the estuary. It has been suggested that its relative abundance in the estuary is inversely proportional to that of the Perth Herring (Serventy, 1955).

Distribution

Western Australia only, from Albany to Port Hedland.

HYPERLOPHUS VITTATUS (CASTELNAU, 1875)

Meletta vittata Castelnau, 1875: 46 (Melbourne, Victoria).

The Sandy Sprat is a marine species which enters the Swan Estuary where it often occurs in sufficient numbers in the summer to be netted for use as bait by anglers.

Distribution

Southern half of Australia (except Tasmania) to Fremantle in Western Australia.

NEMATALOSA VLAMINGHI (MUNRO, 1956)

Fluvialosa vlaminghi Munro, 1956: 25 (Swan River, Western Australia).

During extensive sampling in 1977, all stages in the life cycle of the Perth Herring were found to be very abundant in the middle and upper estuary. Although the Perth Herring is sometimes caught at sea, and many large samples of this species have been collected in Cockburn Sound at times in both the summer and winter, there is evidence that this species can pass through the whole of its life cycle within the Swan-Avon River System.

Distribution

Western Australia only, from the Leschenault Inlet to Broome.

SPRATELLOIDES ROBUSTUS OGILBY, 1897

Spratelloides robustus Ogilby, 1897: 64 (New South Wales).

The Blue Sprat is a marine species which sometimes enters the lower reaches of the Swan Estuary in sufficient numbers to provide at times the basis for a commercial fishery.

Distribution

Southern half of Australia to the Houtman Abrolhos in Western Australia.

ENGRAULIDAE

ENGRAULIS AUSTRALIS (SHAW, 1790)

Atherina australis Shaw (in White), 1790: 296 (near Sydney, New South Wales).

The Southern Anchovy was very abundant in 1977 throughout much of the Swan Estuary. On the basis of vertebral counts, the form in Western Australia has been described by Blackburn (1950) as a separate subspecies, both from *E. australis australis*, which is found in Queensland and much of New South Wales, and from *E. australis antipodum*, which occurs farther south on the eastern seaboard and in Tasmania and South Australia. However, since no description has been published of the alleged Western Australian form, this "subspecies" is not recognized in this paper.

Distribution

New Zealand and the southern half of Australia to Shark Bay in Western Australia.

SALMONIDAE

SALMO TRUTTA LINNAEUS, 1758

Salmo trutta Linnaeus, 1758: 308 (Europe).

The Brown Trout is less abundant in the Swan-Avon River System than the Rainbow Trout but has been recorded in the Canning and Helena Rivers.

Distribution

Introduced into all Australian states except Queensland, and Northern Territory.

SALMO GAIRDNERI RICHARDSON, 1836

Salmo gairdneri Richardson, 1836: 221 (North America).

The Rainbow Trout is abundant in the Swan-Avon River System, particularly above the dam situated on the Canning River (see also Morrissy, 1972).

Distribution

Introduced into all Australian states except Queensland, and Northern Territory.

GALAXIIDAE

GALAXIAS OCCIDENTALIS OGILBY, 1899

Galaxias occidentalis Ogilby, 1899: 157 (south of Perth, Western Australia).

The Western Minnow, which is abundant in fresh water, was only twice caught in the estuary during the extensive sampling programme carried out in 1977 and 1978.

Distribution

Western Australia only, from Albany to Guilderton.

GONORYNCHIDAE

GONORYNCHUS GREYI (RICHARDSON, 1845)

Rhynchana greyi Richardson, 1845: 44 (south-west Western Australia).

The Sand Fish or Beaked Salmon is a marine species occasionally found in the lower reaches of the Swan Estuary.

Distribution

New Zealand and the southern half of Australia to the Houtman Abrolhos in Western Australia.

CYPRINIDAE

CARASSIUS AURATUS (LINNAEUS, 1758)

Cyprinus auratus Linnaeus, 1758: 322 (China).

The Goldfish or Golden Carp is a relatively common introduced species in the freshwater areas of the Canning and the upper catchment areas of the Swan-Avon River System.

Distribution

Worldwide. In Western Australia from the Moore River southwards.

PLOTOSIDAE

CNIDOGLANIS MACROCEPHALUS (VALENCIENNES, 1840)

Plotosus macrocephalus Valenciennes (in Cuvier & Valenciennes), 1840: 317 ('Timor'—probably an error as Kowarsky (1975, 1976) shows that this species is confined to temperate Australian waters).

The Cobbler or Estuary Catfish is represented by a population in the Swan-Avon River System that passes through its entire life cycle in the estuarine regions in which it exhibits seasonal movements (Kowarsky, 1975). Fin ray counts of representatives from the estuary are lower than those recorded for animals collected off the nearby Rottnest Island (Kowarsky, 1975).

Distribution

Southern Queensland, New South Wales, South Australia and to the Houtman Abrolhos in Western Australia.

TANDANUS BOSTOCKI WHITLEY, 1944

Tandanus bostocki Whitley, 1944: 260 (Serpentine River, Western Australia).

One large specimen of the Freshwater Cobbler is present in the WAM collections from the Canning River. This freshwater species is known to occur in the upper reaches of the Canning and Helena Rivers.

Distribution

South-western Western Australia only, from Walpole to Guilderton.

ANTENNARIIDAE

HISTRIO HISTRIO (LINNAEUS, 1758)

Lophius histrio Linnaeus, 1758: 237 (no locality given).

The Sargassum Fish has occasionally been recorded from the lower reaches of the Swan Estuary which it apparently enters from the sea in floating *Sargassum* weed blown in by the wind.

Distribution

Worldwide, preferring warmer waters. In Western Australia it has been found as far south as Safety Bay.

OPHIDIIDAE

DIPULUS CAECUS WAITE, 1905

Dipulus caecus Waite, 1905: 78 (off Fremantle, Western Australia).

Two specimens recorded from the Swan Estuary, the highest locality upriver being Freshwater Bay. The latter specimen is in the WAM collections. This species may be relatively abundant in the rather inaccessible areas of limestone reef of the lower reaches of the estuary.

Distribution

Western Australia only, from Cockburn Sound to Point Quobba, north of Shark Bay.

HEMIRAMPHIDAE

HYPORHAMPHUS REGULARIS REGULARIS (GÜNTHER, 1866)

Hemirhamphus regularis Günther, 1866: 261 (Australia and Western Australia).

Representatives of the Western River Garfish have been caught in various parts of the estuary.

Distribution

Western Australia, from Bunbury to Kalbarri.

HYPORHAMPHUS MELANOCHIR (VALENCIENNES, 1846)

Hemirhamphus melanochir Valenciennes (in Cuvier & Valenciennes), 1846: 41, (Port Western, Victoria).

One specimen of the South Australian or Sea Garfish has been recorded from the Swan Estuary (Collette, 1974: 74).

Distribution

Southern half of Australia to Rottnest Island in Western Australia.

POECILIIDAE

GAMBUSIA AFFINIS (BAIRD & GIRARD, 1853)

Heterandria affinis Baird & Girard, 1853: 390 (North America).

The Mosquito Fish is an introduced freshwater species that is common in the several tributaries of the Swan-Avon River System. From the many sites at which it has been collected in the upper estuary, this teleost is clearly capable of tolerating relatively high salinities in the Swan-Avon. The history of the introduction of *G. affinis* to Western Australia is given by Mees (1977).

Distribution

A species which has been widely introduced to the warmer regions of the world. In Western Australia, it is found from the Fitzgerald River, just west of Hopetoun, to the Hutt River, just north of Geraldton.

ATHERINIDAE

ATHERINOSOMA ELONGATA (KLUNZINGER, 1879)

Atherina elongata Klunzinger, 1879: 394 (King George Sound, Western Australia).

Representatives of the Elongate Hardyhead are found throughout the lower and middle estuary (J. Prince, pers. comm.).

Distribution

Southern half of Australia to Geraldton in Western Australia.

ATHERINOSOMA PRESBYTEROIDES (RICHARDSON, 1843)

Atherina presbyteroides Richardson, 1843: 179 (Port Arthur, Tasmania).

This species is found in large numbers in the middle and upper estuary (J. Prince, pers. comm.).

Distribution

Southern half of Australia to the Houtman Abrolhos in Western Australia.

PRANESUS OGILBYI WHITLEY, 1930

Pranesus ogilbyi Whitley, 1930: 9 (Moreton Bay, Queensland).

Ogilby's Hardyhead is a marine species found throughout the estuary, sometimes in large numbers in the lower and middle estuary.

Distribution

Southern half of Australia to Shark Bay in Western Australia.

VELIFERIDAE

METAVELIFER MULTIRADIATUS (REGAN, 1907)

Velifer multiradiatus Regan, 1907: 633 (north-west Australia).

One juvenile specimen of this species of veifin was collected from Blackwall Reach.

Distribution

Southern half of Australia to Shark Bay in Western Australia. Also known from Lord Howe Island, Mozambique, Japan and Hawaii.

FISTULARIIDAE

FISTULARIA COMMERSONII RÜPPELL, 1835

Fistularia commersonii Rüppell, 1835: 142 (Red Sea).

One juvenile of this species of flutemouth has been collected from the area

of Stirling Bridge near Fremantle. This tropical species has also been recorded from Rottnest Island.

Distribution

Tropical Indo-West Pacific to Fremantle in Western Australia.

SYNGNATHIDAE

HIPPOCAMPUS ANGUSTUS GÜNTHER, 1870

Hippocampus angustus Günther, 1870: 200 (Shark Bay, Western Australia).

Only two specimens of this species of sea horse have been recorded from the Swan Estuary, the highest locality upriver being Crawley Bay. This teleost is common in some sea-grass beds of Cockburn Sound.

Distribution

Western Australia only, from Cockburn Sound to Shark Bay.

STIGMATOPHORA ARGUS (RICHARDSON, 1840)

Syngnathus argus Richardson, 1840: 29 (no locality given).

The Spotted Pipefish is a marine species found in moderate numbers in the lower reaches of the estuary and in abundance in Cockburn Sound.

Distribution

Southern half of Australia to Dongara in Western Australia.

UROCAMPUS CARINIROSTRIS CASTELNAU, 1872

Urocampus carinirostris Castelnau, 1872: 200 (Melbourne, Victoria).

Representatives of the Hairy Pipefish have been caught as far upstream as Belmont. A comparatively rare species in Western Australian waters, having only previously been recorded from Geographe Bay.

Distribution

Southern half of Australia to Fremantle in Western Australia.

SCORPAENIDAE

GYMNAPISTES MARMORATUS (CUVIER, 1829)

Apistus marmoratus Cuvier (in Cuvier & Valenciennes), 1829: 416 ('Timor'—probably an error as this species appears to be confined to southern Australia).

The Devil Fish or South Australian Cobbler is a marine species relatively common as juveniles in the lower estuary. It is abundant in Cockburn Sound.

Distribution

Tasmania, Victoria, South Australia and to Fremantle in Western Australia. Also recently recorded from Port Hacking, N.S.W., by D. Pollard. (pers. comm.).

TRIGLIDAE

CHELIDONICHTHYS KUMU (LESSON, 1830)

Trigla kumu Lesson 1830: 214 (Bay of Islands, New Zealand).

The Red Gurnard is a regular visitor in small numbers to the Swan Estuary where it is caught in prawn seine nets, on handlines and in fish traps. It is common in the coastal waters off Fremantle.

Distribution

Southern half of Australia to Shark Bay in Western Australia. Also known from South Africa, Japan and New Zealand.

PTERYGOTRIGLA POLYOMMATA (RICHARDSON, 1839)

Trigla polyommata Richardson, 1839: 96 (Port Arthur, Tasmania).

The Sharp-beaked Gurnard or Latchet is a marine species found only infrequently in the Swan Estuary. One specimen located in the WAM collections came from a region near Canning Bridge and another has been recorded in Melville Water.

Distribution

Southern half of Australia to Fremantle in Western Australia.

PLATYCEPHALIDAE

PLATYCEPHALUS ENDRACHTENSIS QUOY & GAIMARD, 1824

Platycephalus endrachtensis Quoy & Gaimard, 1824: 353 (Shark Bay, Western Australia).

This flathead is an abundant species throughout the Swan Estuary which may be capable of spending the whole of its life cycle in an estuarine environment.

Distribution

Northern half of Australia southwards to at least Fremantle in Western Australia.

PLATYCEPHALUS HAACKEI STEINDACHNER, 1884

Platycephalus haackei Steindachner, 1884: 1081 (St. Vincent Gulf, South Australia).

The Long-headed Flathead is a marine species that has been infrequently collected from the lower reaches of the estuary. One specimen is present in the WAM collections.

Distribution

South Australia to at least Fremantle in Western Australia.

PLATYCEPHALUS ISACANTHUS CUVIER, 1829

Platycephalus isacanthus Cuvier (in Cuvier & Valenciennes), 1829: 245 (Burou and Waigiou).

One specimen of this marine species has been collected from the lower reaches of the estuary.

Distribution

Indo-West Pacific. Its southern limit in Western Australia is apparently Fremantle.

PLATYCEPHALUS LAEVIGATUS CUVIER, 1829

Platycephalus laevigatus Cuvier (in Cuvier & Valenciennes), 1829: 248 (Port Western, Victoria).

Two specimens of the Rock Flathead have been collected from near the Stirling Bridge at Fremantle. This marine species is moderately abundant in Cockburn Sound but rare in the Swan Estuary.

Distribution

Southern half of Australia to Cockburn Sound in Western Australia.

PEGASIDAE

PARAPEGASUS NATANS (LINNAEUS, 1766)

Pegasus natans Linnaeus, 1766: 418 (India).

A marine species found in relatively large numbers in the lower and seaward end of the middle estuary where it is often taken in prawn seine nets.

Distribution

Tropical Indo-West Pacific. Its southern limit in Western Australia is Cockburn Sound.

PERCICHTHYIDAE

BOSTOCKIA POROSA CASTELNAU, 1873

Bostockia porosa Castelnau, 1873: 126 (Western Australia).

Specimens of this freshwater species in the WAM collections came from the upper reaches of the Helena and Canning Rivers.

Distribution

South-western Western Australia only, from Albany district to Guilderton.

MACCULLOCHELLA PEELI (MITCHELL, 1839)

Acerina (Gristes) peeli Mitchell, 1839 (Peel River, New South Wales).

The Murray Cod was liberated in the upper reaches of the Swan-Avon River System in 1894. Although representatives of this species were recovered seven years later, there have been no further records (Morrissy, 1970).

Distribution

Native to the Murray-Darling river system. Also occurs in a few coastal streams in northern N.S.W. and southern Queensland. Has been successfully introduced into lakes and dams in New South Wales and Victoria.

TERAPONIDAE

AMNIATABA CAUDAVITTATUS (RICHARDSON, 1845)

Datnia? caudavittata Richardson, 1844-8: 24 (Harvey River, south-western Western Australia).

Although workers such as Lake (1971) and Grant (1975) list the Yellow-tailed Trumpeter or Yellow-tailed Perch as an essentially marine teleost, it would appear to live for the whole of its life cycle in predominantly estuarine environments in the Swan-Avon and neighbouring river systems. It is extremely abundant occurring throughout the estuary at least as far upstream as Point Reserve.

Remarks: note that Vari (1978) now uses *Amniataba* and not *Amphitherapon* for this species and that *Pelates* replaces *Helotes* in the case of the following teraponid genus.

Distribution

Northern half of Australia to Cape Leeuwin in Western Australia.

PELATES SEXLINEATUS (QUOY & GAIMARD, 1824)

Terapon sexlineatus Quoy & Gaimard, 1824: 340 (Shark Bay, Western Australia).

The Six-lined Trumpeter or Striped Perch is a marine species which utilizes the Swan Estuary as a nursery ground. Although it was extremely abundant

in the extensive sampling periods of 1977 and early 1978 in the lower reaches, it was also present in relatively large numbers as far upstream as Belmont. Cockburn Sound is also utilized by this species as a nursery ground.

Distribution

Indo-West Pacific including Australia (except Victoria and Tasmania).

PELSARTIA HUMERALIS (OGILBY, 1899)

Therapon humeralis Ogilby, 1899: 177 (Houtman Abrolhos, Western Australia).

The Sea Trumpeter is a common marine species which has been recorded on two occasions from the lower reaches of the estuary.

Distribution

South Australia to the Houtman Abrolhos in Western Australia.

KUHLIIDAE

EDELIA VITTATA CASTELNAU, 1873

Edelia vittata Castelnau, 1873: 124 (Western Australia).

The Western Pygmy Perch is a freshwater species which inhabits the upper reaches of the Swan-Avon River System.

Distribution

South-western Western Australia only, from the Phillips to the Moore Rivers.

APOGONIDAE

APOGON RUEPELLII GÜNTHER, 1859

Apogon rüppellii Günther, 1859: 236 ('Victoria'= Port Essington, Northern Territory).

The Gobbleguts is an abundant marine species in Western Australian waters represented by a large population in the Swan-Avon River System which can spend the whole of its life cycle in the estuarine region of this environment.

Distribution

Although recorded from marine environments near Albany, it has only been taken in estuaries to the north of the Blackwood River. The distribution extends into the Northern Territory.

SIPHAMIA CEPHALOTES (CASTELNAU, 1875)

Scopelus (Neoscopelus) cephalotes Castelnau, 1875: 46 (Adelaide, South Australia).

Two individuals of Wood's Siphon-fish have been caught in the lower estuary. This species is abundant in beds of sea-grass and algae in Cockburn Sound.

Distribution

Southern half of Australia to Fremantle in Western Australia.

PERCIDAE

PERCA FLUVIATILIS LINNAEUS, 1758

Perca fluviatilis Linnaeus, 1758: 289 (Europe).

The Redfin or European Perch is a freshwater species which was introduced into Lake Leschenaultia. Representatives of this species were recently collected by members of the Department of Fisheries and Wildlife.

Distribution

Introduced to many countries throughout the world.

SILLAGINIDAE

SILLAGINODES PUNCTATUS (CUVIER, 1829)

Sillago punctata Cuvier (in Cuvier & Valenciennes), 1829: 413 (King George Sound, Western Australia).

The King George or Spotted Whiting, which is a marine species that occasionally enters the estuary during the first year of life, is much less abundant in the Swan Estuary than the Trumpeter Whiting, *Sillago maculata*.

Distribution

Southern half of Australia to Fremantle in Western Australia.

SILLAGO MACULATA QUOY & GAIMARD, 1824

Sillago maculata Quoy & Gaimard, 1824: 261 (Sydney, New South Wales).

The Trumpeter Whiting is a marine species which utilizes many areas in the estuary as a nursery ground, being found in large numbers in Perth and Melville Waters during the summer. Adults are present in marine embayments such as Cockburn Sound where they are very abundant during the summer months (Penn, 1977).

Distribution

Northern half of Australia to Fremantle in Western Australia. Also known from the Indo-Malay Archipelago.

SILLAGO SCHOMBURGKII PETERS, 1865

Sillago schomburgkii Peters, 1865: 391 (Adelaide, South Australia).

The Western Sand or Yellow-finned Whiting is a marine species normally utilizing the shallow sandy areas of the estuary as a nursery ground. Like *Sillaginodes punctatus*, it is much less abundant in the Swan than *Sillago maculata*.

Distribution

South Australia to Shark Bay in Western Australia.

POMATOMIDAE

POMATOMUS SALTATRIX (LINNAEUS, 1766)

Gasterosteus saltatrix Linnaeus, 1766: 491 (East Coast, North America).

The Tailor is a marine species which utilizes the estuary as a feeding ground at various times during post-larval life. In years of heavy freshwater discharge, the numbers are relatively much lower in the winter months.

Distribution

Worldwide.

RACHYCENTRIDAE

RACHYCENTRON CANADUM (LINNAEUS, 1766)

Gasterosteus canadus Linnaeus, 1766: 491 (Carolina, North America).

Juvenile specimens of this pelagic marine species, known as the Cobia or Black Kingfish, have been collected infrequently from as far upriver as Freshwater Bay.

Distribution

Worldwide (except eastern Pacific), preferring warmer waters. In Western Australia, it ranges as far south as Cape Naturaliste.

CARANGIDAE

ALECTIS CILIARIS (BLOCH, 1787)

Zeus ciliaris Bloch, 1787: 36 (East Indies).

One small juvenile of the Pennant Trevally has been collected from the channel region in the lower estuary. This tropical species has previously been collected from the sea off Floreat Beach, just north of Fremantle.

Distribution

Widespread in tropical regions of the world including Western Australia where this specimen constitutes its southernmost record.

CARANX GEORGIANUS CUVIER, 1833

Caranx georgianus Cuvier (in Cuvier & Valenciennes), 1833: 85 (King George Sound, Western Australia).

The Skipjack Trevally is a marine species which as juvenile stages frequently enter the middle and lower estuary.

Distribution

South Australia to the Houtman Abrolhos in Western Australia.

SERIOLA HIPPOS GÜNTHER, 1876

Seriola hippos Günther, 1876: 392 (Sydney, New South Wales).

The marine Samson Fish is occasionally caught in the lower reaches of the estuary. One specimen from Freshwater Bay is housed in the WAM collection. Juveniles of this species are sometimes found in large numbers in Cockburn Sound (Penn, 1977).

Distribution

Southern Queensland, New South Wales, South Australia and to Shark Bay in Western Australia.

TRACHURUS MCCULLOCHI NICHOLS, 1920

Trachurus mccullochi Nichols, 1920: 479 (South Australia).

Large numbers of o-group and young adults of this marine species, known as the Yellowtail Scad, are found in the middle and lower estuary, particularly during the warmer months.

Distribution

Southern half of Australia to North West Cape in Western Australia.

ARRIPIDAE

ARRIPIS GEORGIANUS VALENCIENNES, 1831

Centropristis georgianus Valenciennes (in Cuvier & Valenciennes), 1831: 451 (King George Sound, Western Australia).

A number of specimens of the Australian Herring or Tommy Rough were collected from the Maylands region of the river during May 1977. Observations by fishermen suggest that this species is a regular visitor to the river in the late summer and autumn.

Distribution

Southern half of Australia to Shark Bay in Western Australia.

ARRIPIS TRUTTA ESPER WHITLEY, 1951

Arripis trutta esper Whitley, 1951: 66 (Fremantle, Western Australia).

The Australian Salmon is a marine species which is reported occasionally to enter the lower reaches of the Swan Estuary.

Distribution

Tasmania, Victoria, South Australia and to Shark Bay in Western Australia.

NEMIPTERIDAE

PENTAPODUS VITTA QUOY & GAIMARD, 1824

Pentapodus vitta Quoy & Gaimard, 1824: 294 (Shark Bay, Western Australia).

The Butterfish, which is a common marine species in Cockburn Sound (Penn, 1977), enters the lower reaches of the Swan Estuary in small numbers.

Distribution

Western Australia only, from Cockburn Sound to Exmouth Gulf.

GERRIDAE

GERRES SUBFASCIATUS CUVIER, 1830

Gerres subfasciatus Cuvier (in Cuvier & Valenciennes), 1830: 477 (Port Jackson, New South Wales).

This species of silverbelly is apparently represented in the Swan-Avon by populations which pass through the whole of their life cycle in the estuary.

Remarks: The identity of this species is not certain. It has been referred to as *G. australis* (misidentification), *G. ovatus* and possibly *G. baconensis*. The oldest available name is used here.

Distribution

Northern half of Australia to Cockburn Sound in Western Australia.

SPARIDAE

ACANTHOPAGRUS BUTCHERI (MUNRO, 1949)

Mylio butcheri Munro, 1949: 191 (Gippsland Lakes, Victoria).

The Black Bream is an abundant species in the Swan-Avon River System, living predominantly in the upper and middle estuary. It may occasionally be found, however, in the lower reaches and can be flushed out to sea during periods of heavy freshwater discharge. In this context it is worth noting that collection sites for paratypes include Shark Bay and Houtman Abrolhos.

Distribution

Southern New South Wales, Tasmania, Victoria, South Australia and to at least Kalbarri, in Western Australia.

CHRYSOPHRYS UNICOLOR QUOY & GAIMARD, 1824

Chrysophrys unicolor Quoy & Gaimard, 1824: 299 (Shark Bay, Western Australia).

A large adult specimen of the Pink Snapper has been recorded from Blackwall Reach. Although juveniles of this species are known to enter more southern estuaries, there is no current evidence that it passes into the Swan Estuary at this stage in its life cycle. This contrasts with the situation in Cockburn Sound where large numbers of o-group individuals are present (Lenanton, 1974b). Recent data obtained by Penn (1977) also suggests that Cockburn Sound is an important nursery and breeding ground for this species.

Distribution

South Australia to Shark Bay in Western Australia.

RHABDOSARGUS SARBA (FORSSKÅL, 1775)

Sparus sarba Forsskål, 1775: 31 (Red Sea).

The Tarwhine or Silver Bream is a marine species which very occasionally enters the lower and middle estuary.

Distribution

Indo-West Pacific. Southern limit in Western Australia is Beaufort Inlet, east of Albany.

SCIAENIDAE

ARGYRO SOMUS HOLOLEPIDOTUS (LACÉPÈDE, 1802)

Labrus hololepidotus Lacepède, 1802: 448 (locality not known).

Sciaena antarctica Castelnau, 1872: 100 (Melbourne, Victoria).

The Mulloway or River Kingfish is a marine species which utilizes the estuary as a nursery area and adult feeding ground. It is also abundant in Cockburn Sound where it is an important angling fish (Penn, 1977).

Distribution

From Cape York, around the southern coastline of Australia to Onslow in north-western Western Australia.

MULLIDAE

PARUPENEUS FRATERCULUS (VALENCIENNES, 1831)

Upeneus fraterculus Valenciennes (in Cuvier & Valenciennes), 1831: 524 (Seychelles).

Two juveniles of the Blackspot Goatfish have been collected from the region of the Stirling Bridge at Fremantle. This tropical species is relatively common in some shallow water areas at Rottnest Island.

Distribution

Widespread in the Indo-West Pacific including Western Australia where Rottnest Island is its southern limit.

PEMPHERIDAE

PEMPHERIS KLUNZINGERI McCULLOCH, 1911

Pempheris klunzingeri McCulloch, 1911: 47 (King George Sound, Western Australia).

One specimen of this marine species, commonly known as the Rough Bullseye, has been recorded from the lower reaches of the estuary.

Distribution

South Australia to the Houtman Abrolhos in Western Australia.

KYPHOSIDAE

KYPHOSUS SYDNEYANUS (GÜNTHER, 1886)

Pimelepterus sydneyanus Günther, 1886: 368 (Port Jackson, New South Wales).

The Silver Drummer or Buffalo Bream is a common marine species represented in the records for the Swan-Avon River System by a single juvenile taken from Blackwall Reach.

Distribution

Southern half of Australia to the Houtman Abrolhos in Western Australia.

SCORPIDIDAE

NEATYPUS OBLIQUUS WAITE, 1905

Neatypus obliquus Waite, 1905; 65 (Houtman Abrolhos, Western Australia).

There is only a single specimen from the Swan-Avon River System of the Footballer Sweep in the WAM collections, this coming from Guildford. This marine species is common, however, on the reefs off Fremantle.

Distribution

Western Australia, from the Archipelago of the Recherche to the Houtman Abrolhos.

ENOPLOSIDAE

ENOPLOSUS ARMATUS (SHAW, 1790)

Chaetodon armatus Shaw (in White), 1790: 254 (Sydney, New South Wales).

The Old Wife is a marine species and has been recorded from just north of the Fremantle Bridge and at Blackwall Reach. It is a rare visitor to the Swan Estuary and does not apparently penetrate far into the system.

Distribution

Southern half of Australia to the Houtman Abrolhos in Western Australia.

CICHLIDAE

TILAPIA ZILLII (GERVAIS, 1848)

Acerina zillii Gervaise, 1848: 203 (Tuggurth, Algeria).

This freshwater species was found during July 1975 in a system of closed and open drains and small ponds in the Bayswater area adjacent to the upper estuary. This population is believed to have been successfully removed by members of the Department of Fisheries and Wildlife and the Western Australian Museum employing seine nets and rotenone in August 1975. The fish were apparently brought into Western Australia for the aquarium trade and later discarded into this drainage system. Biological analysis of the specimens collected showed that many were in an immediate pre-spawning condition (M. Walker, pers. comm.).

Distribution

North Africa, Jordan and Syria.

CHEILODACTYLIDAE

CHEILODACTYLUS GIBBOSUS RICHARDSON, 1841

Cheilodactylus gibbosus Richardson, 1841; 21 and 102 (Western Australia).

The Crested Morwong is a marine species frequently encountered in the Swan Estuary and is represented in the WAM by specimens from as far upriver as Belmont.

Distribution

Western Australia only, from the Archipelago of the Recherche to Shark Bay.

MUGILIDAE

ALDRICHETTA FORSTERI (VALENCIENNES, 1836)

Mugil forsteri Valenciennes (in Cuvier & Valenciennes), 1836: 141 (New Zealand).

Representatives of o-group and adults of the Yellow-eye or Freshwater Mullet have been taken in large numbers in many areas of the Swan Estuary throughout the year. While this species moves out to sea during the winter to spawn in Western Australia, it breeds in the summer in other parts of Australia (Thomson, 1957d, 1966).

Distribution

Southern half of Australia to Shark Bay in Western Australia.

MUGIL CEPHALUS LINNAEUS, 1758

Mugil cephalus Linnaeus, 1758: 316 (European seas).

Like the Yellow-eye Mullet, the Sea Mullet uses much of the Swan Estuary at various stages of its life cycle and spawns in the winter at sea (Thomson, 1957d, 1966; Chubb *et al.*, unpublished data). However, the adults of the Sea Mullet are predominantly detritivores, whereas those of the Yellow-eye Mullet are omnivorous (Thomson, 1957, 1966).

Distribution

Worldwide, in temperate and tropical seas.

SPHYRAENIDAE

SPHYRAENA OBTUSATA CUVIER, 1829

Sphyraena obtusata Cuvier (in Cuvier and Valenciennes), 1829: 350 (Port Jackson, New South Wales).

One small specimen of the Striped Sea Pike has been collected from the Stirling Bridge area at Fremantle. This marine species is common in the waters off Fremantle.

Distribution

Indo-West Pacific and southern Australia.

ODACIDAE

NEOODAX BALTEATUS (VALENCIENNES, 1839)

Odax balteatus Valenciennes (in Cuvier & Valenciennes), 1839: 303 (no locality given).

Several specimens of this species of rock whiting have been collected from the Stirling Bridge area at Fremantle. It is relatively common in the shallow sea-grass beds of Cockburn Sound.

Distribution

Southern half of Australia to Fremantle in Western Australia.

NEOODAX SEMIFASCIATUS (VALENCIENNES, 1839)

Odax semifasciatus Valenciennes (in Cuvier & Valenciennes), 1839: 299 (Indian Ocean).

The Blue Rock or Weedy Whiting is found in small numbers in the weed beds in the lower reaches of the estuary.

Distribution

Southern half of Australia to Lancelin in Western Australia.

OLISTHOPS CYANOMELAS RICHARDSON, 1850

Olisthops cyanomelas Richardson, 1850: 75 (King George Sound, Western Australia).

The single specimen of the Herring Cale from the Swan Estuary in the WAM collections is the only known record of this marine teleost from a Western Australian estuary.

Distribution

Southern half of Australia to Lancelin in Western Australia.

BLENNIIDAE

OMOBRANCHUS GERMAINI (SAUVAGE, 1883)

Petroscirtes germaini Sauvage, 1883: 158 (New Caledonia).

One small individual of Germain's Blenny has been collected from Black-wall Reach. This tropical species is common at Rottnest Island.

Distribution

Tropical western Pacific and Western Australia where Cockburn Sound is the southern limit of its range.

PICTIBLENNIUS TASMANIANUS (RICHARDSON, 1849)

Blennius tasmanianus Richardson, 1849: 129 (Port Arthur, Tasmania).

This marine species of blenny is frequently found living around wharf piles at least as far up the Swan-Avon River System as Canning Bridge.

Distribution

Southern half of Australia to the Houtman Abrolhos in Western Australia.

CLINIDAE

CRISTICEPS AUSTRALIS VALENCIENNES, 1836

Cristiceps australis Valenciennes (in Cuvier & Valenciennes), 1836: 402 (Tasmania).

The Crested Weedfish is a marine species, which frequents sea-grass beds, and is represented in the WAM collections by a small number of specimens from the lower reaches of the estuary.

Distribution

Southern half of Australia to the Houtman Abrolhos in Western Australia.

CALLIONYMIDAE

CALLIONYMUS GOODLADI (WHITLEY, 1944)

Calliurichthys goodladi Whitley, 1944: 270 (Cheyne Beach, Western Australia).

Goodlad's Dragonet, which is found in abundance in Cockburn Sound, is present in some numbers in the lower estuary.

Distribution

Western Australia only, from Cheyne Beach east of Albany to Exmouth Gulf.

CALLIONYMUS PAPILIO GÜNTHER, 1864

Callionymus papilio Günther, 1864: 197 (Melbourne, Victoria).

The Painted Stinkfish or Painted Dragonet is a marine species which is found in small numbers in sea-grass beds in the lower estuary.

Distribution

Southern half of Australia to Rottnest Island in Western Australia.

DACTYLOPUS DACTYLOPUS (VALENCIENNES, 1837)

Callionymus dactylopus Valenciennes (in Cuvier & Valenciennes), 1837: 31 (no locality given).

One specimen of the Fingered Dragonet, which is a marine species, has been collected in a fish trap set in Blackwall Reach (WAM collections). This is one of several examples of a tropical species being found in an estuary at the limit of its range.

Distribution

Indonesia, Malaysia and the Philippines to northern Australia where Cockburn Sound appears to be its southern limit in Western Australia.

GOBIIDAE

AMOYA BIFRENATUS (KNER, 1865)

Gobius bifrenatus Kner, 1865: 177 (Sydney, New South Wales).

The Bridled Goby is apparently a true estuarine species found in moderately large numbers through the Swan Estuary, particularly in the middle and upstream areas where it burrows into 'muddy' substrates.

Distribution

Southern half of Australia to Fremantle in Western Australia.

FAVONIGOBIUS LATERALIS (MACLEAY, 1881)

Gobius lateralis Macleay, 1881: 602 (southern Australia).

The Long-finned Goby is present throughout the estuary in moderately large numbers, more particularly in the middle and lower estuary. It is also common in Cockburn Sound.

Distribution

Southern half of Australia to the Houtman Abrolhos in Western Australia.

FAVONIGOBIUS SUPPOSITUS (SAUVAGE, 1880)

Gobius suppositus Sauvage, 1880: 41 (Swan River, Western Australia).

The South-west or Long-headed Goby is found in moderate abundance in the Swan-Avon River System, particularly in the more upstream reaches.

Distribution

Western Australia, from Albany to Guilderton.

PSEUDOGOBIUS OLORUM (SAUVAGE, 1880)

Gobius olorum Sauvage, 1880: 43 (Swan River, Western Australia).

The Blue-spot Goby, which has been found in fresh water lakes (N. Sarti,

pers. comm.) and in saline lakes (Mutton, 1973), is present in many regions of the estuary.

Distribution

Western Australia, from Esperance to Kalbarri.

TRIDENTIGER TRIGONOCEPHALUS (GILL, 1858)

Triaenophorus trigonocephalus Gill, 1858: 17 (China).

The Japanese Goby is an estuarine species which has been introduced from Japan, probably through shipping activities (Hoese, 1973). Ten individuals have been collected in recent years.

Distribution

Japan but also reported from Los Angeles Harbour and San Francisco Bay, U.S.A., and Sydney Harbour, Australia.

SCOMBRIDAE

THUNNUS ALBACARES (BONNATERRE, 1788)

Scomber albacares Bonnaterre, 1788: 140 (Madeira).

One specimen of this pelagic marine species, commonly known as the Yellow-fin Tuna, has been recorded from Perth Water.

Distribution

Indian and Pacific Oceans.

BOTHIDAE

PSEUDORHOMBUS JENYNSII (BLEEKER, 1855)

Platessa jenynsii Bleeker, 1855: 15 (Tasmania).

Two specimens of the Small-toothed Flounder from the Swan-Avon River System are present in the WAM collections. Many representatives of o-group

individuals and adults of this marine species were also caught in numbers in the lower end of the estuary during the 1977-78 survey.

Distribution

Southern half of Australia to Shark Bay in Western Australia.

PLEURONECTIDAE

AMMOTRETIS ELONGATUS McCULLOCH, 1914

Ammotretis elongatus McCulloch, 1914: 123 (South Australia).

Three specimens of the Elongate Flounder taken in Freshwater Bay are located in WAM collections. WAM records suggest that this marine teleost may sometimes be present in numbers on the sand flats of the lower reaches of the estuary.

Distribution

South Australia to Fremantle in Western Australia.

CYNOGLOSSIDAE

CYNOGLOSSUS MACULIPINNIS RENDAHL, 1921

Cynoglossus maculipinnis Rendahl, 1921: 17 (north-west Australia).

This species of tongue sole is found in some numbers in the lower estuary.

Distribution

Northern half of Australia to Fremantle in Western Australia.

MONACANTHIDAE

BIGENER BROWNII (RICHARDSON, 1844-8)

Aleuterius? brownii Richardson, 1844-8: 68 (Australia).

One juvenile specimen of the Spiny-tailed Leatherjacket has been recorded from Blackwall Reach. This marine species is common in Cockburn Sound.

Distribution

Southern half of Australia (except Tasmania) to Lancelin in Western Australia.

CHAETODERMA PENICILLIGERA (CUVIER, 1817)

Monacanthus penicilligerus Cuvier, 1817: 185 (no locality given).

One specimen of the Weedy Leatherjacket has been collected from near Stirling Bridge at Fremantle. This tropical species is infrequently taken in Cockburn Sound.

Distribution

Indo-West Pacific to Geographe Bay in Western Australia.

EUBALICHTHYS MOSAICUS (RAMSAY & OGILBY, 1886)

Monacanthus mosaicus Ramsay & Ogilby, 1886: 5 (Port Jackson, New South Wales).

Specimens of the Mosaic Leatherjacket from Mosman Bay and Maylands are located in the WAM collections. Although this marine species prefers offshore reefs, juveniles are occasionally taken from estuaries. However, it would not be expected to penetrate very far up river.

Distribution

Southern half of Australia to Beagle Island, south of Geraldton, in Western Australia.

MEUSCHENIA FREYCINETI (QUOY & GAIMARD, 1824)

Balistes freycineti Quoy & Gaimard, 1824: 213 ('Mauritius'—an error, should be Australia).

Juveniles of the Six-spined Leatherjacket collected from sea-grass beds at Blackwall Reach are present in the WAM collections, and have also been obtained in trawls and seines from the same area. In the estuaries further south, however, the o-group and young adults are relatively common, with the adults inhabiting offshore waters.

Distribution

Southern half of Australia to Mullaloo, just north of Fremantle in Western Australia.

MONACANTHUS CHINENSIS (OSBECK, 1765)

Balistes chinensis Osbeck, 1765: 147 (China).

The Fan-bellied Leatherjacket is relatively common in the lower reaches of the estuary especially near Fremantle Harbour. Specimens have been collected in sea-grass beds at Blackwall Reach. Although this species is considered marine, it appears to be able to tolerate reduced salinities (Hutchins, unpublished data).

Distribution

Indo-West Pacific, including Western Australia where Cockburn Sound appears to be its southern limit.

SCOBINICHTHYS GRANULATUS (SHAW, 1790)

Balistes granulata Shaw (in White), 1790: 295 (near Sydney, New South Wales).

The Rough Leatherjacket is commonly represented by o-group individuals in the lower reaches of the estuary.

Distribution

Southern half of Australia to Shark Bay in Western Australia.

OSTRACIONTIDAE

ANOPLOCAPROS LENTICULARIS (RICHARDSON, 1841)

Ostracion lenticularis Richardson, 1841: 21 (Australia).

One specimen is this marine species, known as the White-barred Boxfish, has been recorded for the Swan-Avon from Melville Water.

Distribution

South Australia to Lancelin in Western Australia.

ARACANA AURITA (SHAW, 1798)

Ostracion auritus Shaw, 1798: pl. 338 ('Islands of the Pacific Ocean,' possibly Tasmania).

One specimen of the marine Shaw's Boxfish or Shaw's Cowfish has been recorded from the Swan Estuary in Crawley Bay.

Distribution

Victoria, Tasmania, South Australia and to Kalbarri in Western Australia.

TETRAODONTIDAE

AROTHRON HISPIDUS (LINNAEUS, 1758)

Tetraodon hispidus Linnaeus, 1758: 333 (India).

The Lined Pufferfish was recorded from the Swan-Avon River System as *Ovalides reticularis* by Glauert (1949: 45). The above specimen is in the WAM collections, together with another from the Fremantle region of the estuary. The presence of this coral reef species in the Swan is surprising in view of the fact that it has not been recorded in the waters off Fremantle. However, as Bennett and Pope (1953: 141) point out, warmer water species may temporarily extend their range into colder waters by living in the shallower areas of estuaries where the summer water temperatures are considerably higher than those encountered in the nearby ocean.

Distribution

Tropical Indo-West Pacific to Fremantle in Western Australia.

CONTUSUS RICHEI (FRÉMINVILLE, 1813)

Tetrodon richei Fréminville, 1813: 250 (no locality given).

Three specimens of the Prickly Pufferfish or Prickly Toadfish have been recorded from Blackwall Reach and another from Freshwater Bay. This marine species is apparently rarer in the Swan Estuary than in the more southern estuaries and embayments of Western Australia.

Distribution

Southern half of Australia to Green Head, just north of Jurien Bay in Western Australia.

LAGOCEPHALUS SCELERATUS (GMELIN, 1788)

Tetrodon sceleratus Gmelin, 1788: 1444 (New Caledonia).

One specimen of the North-west Blowfish or Silver Toadfish has been recorded from the Swan Estuary in Crawley Bay.

Distribution

Indo-West Pacific to the southern waters of Western Australia.

TORQUIGENER PLEUROGRAMMA (REGAN, 1903)

Tetrodon pleurogramma Regan, 1903: 300 (New South Wales).

The Banded Toadfish or Common Blowfish has clearly been extremely abundant for many years in the lower and middle estuary.

Distribution

Southern Queensland, New South Wales, Lord Howe Island, South Australia and to Shark Bay in Western Australia.

DIODONTIDAE

ATOPOMYCTERUS NICTHEMERUS (CUVIER, 1818)

Diodon nictemerus Cuvier, 1818: 135 (Indian Ocean).

One specimen of the Globe Fish, which is a marine species, has been recorded in the Swan Estuary from Blackwall Reach.

Distribution

South Australia to Lancelin in Western Australia.

DISCUSSION

The checklist presented in this paper demonstrates that a relatively abundant fish fauna is present in the Swan-Avon River System. It is also clear that most of the 110 species, representing 64 families, are fishes whose life cycles are spent in predominantly marine or estuarine conditions.

Indigenous and introduced freshwater species

Indigenous freshwater teleosts are represented in the Swan-Avon River System by only one galaxiid (*Galaxias occidentalis*), one plotosid (*Tandanus bostocki*), one percichthyid (*Bostockia porosa*) and a single kuhliid (*Edelia vittata*). The paucity of this fauna parallels the situation found in other south-western Australian rivers (Lake, 1971). There are however certain factors which have also almost certainly contributed to the relatively small populations representing each of these indigenous species. For example, two of the main tributaries, the Canning and the Helena, are not only of relatively small length but are also dammed. Moreover, the third, namely the Avon, although consisting of a widely ramifying catchment system, suffers from eutrophication, periods of extensive 'drying-up' and an increased ionic concentration due to run-off from the surrounding agricultural land (Kendrick, 1976; Morrissy, pers. comm.).

While only four indigenous freshwater species are currently found in the Swan-Avon, this river system does contain a number of introduced freshwater teleosts which have flourished in the changed conditions brought about by damming. Thus, Goldfish, *Carassius auratus*, Brown Trout, *Salmo trutta*, Rainbow Trout, *Salmo gairdneri*, and Redfin Perch, *Perca fluviatilis*, have taken advantage of either the sluggish areas or the continuous flow that have resulted from the construction of dams. The same is also true of the Mosquito Fish, *Gambusia affinis*, which was introduced in an attempt to control local mosquito populations (Mees, 1977). Other introduced species include *Tilapia zillii*, which was brought into Western Australia as an aquarium fish, but in recent years has been found only in one small tributary (M. Walker, pers. comm.). The remaining introduced species, the Murray Cod, *Maccullochella peelii*, was brought into the Avon from South Australia (Morrissy, 1970). Since individuals later attained weights of nearly 20 kg, they were clearly capable of feeding and growing for at least a short period of time. The lack of any subsequent records for this species can apparently be attributed to the absence of conditions suitable for spawning. The success, however, of some of the above introduced fish must also be another factor which has contributed to the current paucity in the numbers of the indigenous freshwater teleost fauna.

The Swan Estuary as a nursery habitat and adult feeding ground

In common with most estuaries, the Swan Estuary acts as a nursery ground for a number of marine teleosts. Two species that enter the estuary in large numbers, and predominantly only in their first year of life, are the Six-lined Trumpeter, *Pelates sexlineatus*, and the Trumpeter Whiting, *Sillago maculata*, which start their inwards movement during the summer months. The Yellow-eye and Sea Mulletts, *Aldrichetta forsteri* and *Mugil cephalus*, represent another group of teleosts that is abundant in the Swan Estuary, but in this case utilize the estuary extensively as an adult feeding area as well as a nursery habitat. These species, and in particular the Sea Mullet, sometimes spend, however, a considerable time at sea, including their spawning period (Thomson, 1957d; 1966). Other abundant species that follow a similar life cycle pattern in the Swan and other south-western estuaries are the Tailor, *Pomatomus saltatrix*, and the Mulloway, *Argyrosomus hololepidotus*.

Marine teleosts, which use the estuary predominantly after the completion of their first year of life, are represented by such species as the Common Blowfish, *Torquigener pleurogramma*. This fish is often so numerous that samples taken in our 103m long beach seine have sometimes contained nearly 1000 individuals with total lengths generally falling in the range of 10-20 cm.

Species which can pass through the whole of their life cycle within the Swan-Avon River System

One aspect emerging from our recent regular sampling programme is that evidence is now available that a number of species in the Swan-Avon River System are represented by populations that can pass through the whole of their life cycle in an estuarine environment. There would appear to be little doubt, for example, that several gobiids, such as the Long-headed, *Favonigobius suppositus*, Bridled, *Amoya bifrenatus*, and Blue-spot Gobies, *Pseudogobius olorum*, fall into this category. This view is also supported by the observations of Lenanton (1977a) on these species in the Blackwood River. Another fish which has been termed by Lenanton (1977a) as estuarine in the Blackwood is the Black Bream, *Acanthopagrus butcheri*. Our study indicates that, although representatives of this species may occasionally be swept out to sea in the winter, all year classes are abundant in the upper and middle estuary during the summer. This estuarine mode of life in the Swan-Avon contrasts with their marine distribution in South Australia (Weng, 1970).

The Cobbler, *Cnidoglanis macrocephalus*, differs from the Black Bream in that it is represented by populations in the estuarine regions of the Swan-Avon River System and in the sea. Moreover, the populations off the nearby Rottneest

Island have been shown to differ in meristic and other characters (Kowarsky, 1975).

In the context of estuarine populations, the Yellow-tailed Trumpeter, *Amniataba caudavittatus*, which is numerous in the Swan-Avon River System, provides another parallel with the Black Bream. Thus, while our studies strongly suggest that this species rarely goes out to sea in the region surrounding the Swan-Avon, it has been found in marine embayments, such as those of Shark Bay to the north (Lenanton, 1977b). Its restriction to the estuarine regions of the Swan-Avon in the Perth area of Western Australia is of interest as it is known to be able to tolerate salinities of 52‰ in the lagoon regions of Shark Bay (Lenanton, 1977b).

Our studies on the last few species highlight the problem of establishing whether several of the fishes in the Swan-Avon River System should be regarded as true estuarine species. A further instance of this dilemma is provided by the Perth Herring, *Nematalosa vlaminghi*, which is abundant in the Swan-Avon throughout the year and for which there is evidence that breeding takes place in the upper regions of the river. At the same time, it must be noted, however, that large numbers of individuals have been taken occasionally from Cockburn Sound in the summer and the winter. At the present time, we are of the opinion that in the Swan-Avon region of Western Australia, the Perth Herring is an estuarine species which may sometimes move into oceanic marine embayments.

Although there can be little doubt that the Perth Herring, in common with the closely related *Nematalosa come* (Thomson, 1957e), occasionally moves for considerable periods into low salinities, or even freshwater, the same cannot apparently be said for the Gobbleguts, *Apogon rueppellii*. During our recent sampling programme, populations of this latter species moved in under the halocline during the winter, a feature which may well be an adaptation to reduce its exposure to declines in salinity brought about during periods of freshwater flushing. This species, which can undoubtedly pass through the whole of its life cycle in the estuary, is also abundant at all stages in Cockburn Sound and in small numbers off Rottnest Island. Another teleost which we currently consider as estuarine is the western form of the Anchovy, *Engraulis australis*. This species, which was extremely numerous in the Swan Estuary during 1977, is also very common in several other south-western Australian estuaries.

It is clear from the presence in the Swan-Avon of large populations of several of the species just mentioned that this river system possesses certain characteristics conducive to their spending the whole of their life cycle in estuarine

conditions. Our future studies will be aimed at elucidating the factors which are responsible for the success in the Swan-Avon River System of such species as the Perth Herring, Yellow-tailed Trumpeter and Gobbleguts.

Marine stragglers

The foregoing attempt at categorising the teleosts found in the Swan River on the basis of data on their life cycle was restricted to the more abundant species. By far the majority of the fish in our checklist were, however, what might be termed marine 'stragglers.' In other words, they are species, usually represented by older individuals, that are typically marine, but which have entered the lower reaches of the estuary for a restricted period. One such species is the Red Gurnard, *Chelidonichthys kumu*, which has been caught in small numbers in several different years, while more limited records are available for other teleosts such as the Lined Pufferfish, *Arothron hispidus*, the North-West Blowfish, *Lagocephalus sceleratus*, and the White-barred Boxfish, *Anoplocapros lenticularis*.

Cartilagenous fishes

In terms of the cartilagenous fishes, it would clearly appear from the checklist that this group is poorly represented in the Swan. Thus, in addition to single records for a hammerhead shark, *Sphyrna zygaena*, the Port Jackson Shark, *Heterodontus portusjacksoni*, the Shovelnose Ray, *Aptychotremata vincentiana*, and an eagle ray, *Myliobatis australis*, the only other elasmobranch recorded from the Swan-Avon River System is the Swan River Whaler, *Carcharhinus leucas*, which, in addition to the records mentioned under the species notes, has been caught on lines used for catching Mulloway. A study of the biology of this species would be of considerable interest in view of the lack of records from nearby marine habitats.

Comparisons with other Western Australian Estuaries.

The checklist and brief notes on the biology of some of the more abundant fish species in the Swan-Avon River System can be compared with the results of Lenanton's (1977a) extensive study of the Blackwood River Estuary, approximately 252 km to the south. In considering the species whose distribution range clearly encompasses both river systems, the most notable differences reside in the virtual absence or small numbers in the Swan of the Pink Snapper, *Chrysophrys unicolor*, and the restricted numbers of the Sea Garfish *Hyporhamphus melanochir*, Silver Bream, *Rhabdosargus sarba*, Six-spined Leatherjacket, *Meuschenia freycineti*, and the Western Sand and King

George Whittings, *Sillago schomburgkii* and *Sillaginodes punctatus*. Most of these are represented by large numbers in the Blackwood and in inlets to the south of the Swan-Avon, as well as being very common off the coastal regions around Perth where they make a considerably contribution to the commercial and amateur fishery. In this context, it is therefore probably of significance that the underwater observations of one of us (J.B.H.) demonstrate that these fishes in particular tend to move away from areas of disturbance. These species may thus tend to avoid entering the Swan-Avon because of the frequent and extreme disturbance created in the water and river bottom by the movement of the many large ships that enter the narrow Fremantle Harbour which is located in the lower estuary.

A major difference can also be observed between the fish fauna of the two most studied Western Australian estuaries by the fact that four of the currently most abundant teleosts in the Swan-Avon, are absent from the Blackwood. Furthermore, the numbers of these species, namely the Perth Herring, Yellow-tailed Trumpeter, Gobbleguts and a species of silverbelly, *Gerres subfasciatus*, apparently decline abruptly in a region to the south of Perth. This point is well illustrated by the contrast between their absence in the Blackwood and their relatively high abundance in Leschenault Inlet only 117 km further to the north (R.C.L. unpublished data). It should also be noted that the Giant Herring, *Elops machnata*, is the only predominantly northern species that has been found in the Blackwood (Lenanton, 1977a). The Swan Estuary by contrast is characterised by possessing several species of tropical 'stragglers,' a feature which is largely responsible for the fact that it contains almost twice as many species as have been found in the Blackwood Estuary.

The current studies of Lenanton (unpublished) make it clear that the Murchison River, which is located 511 km to the north of Perth, contains a fauna similar in composition to that of the Swan-Avon. Thus, the predominant fishes are species such as the Perth Herring, Gobbleguts, Black Bream, Yellow-tailed and Six-lined Trumpeters, and Sea Mullet, all of which have also been recorded further north. The only real exceptions in the fauna of the Murchison reside in the presence of the Jumping or Flat-tail Mullet, *Liza argentea*, and the higher proportion of 'stragglers' of genuine tropical species. The large numbers of *L. argentea* in the Murchison, and also in the Greenough approximately 142 km further south, is surprising in view of the fact that this species is also present in South Australia (Scott *et al.*, 1974), but not in the estuaries of the south west (Lenanton, 1974a, 1977a).

Although the amount of information on Western Australian coastal rivers and estuaries is extremely limited, it would clearly appear from the above

data, and from marine records, that some of the fish found in north-western Australia have distributions which extend southwards to a region corresponding approximately to Cape Naturaliste. This finding parallels the situation described by Wilson & Gillett (1974) for gastropods, who regard the latter area as representing the most southern location to which representatives of their Northern Australian Region (Tropical) extend.

From a sampling programme carried out in south-western estuaries by Lenanton (1974a), it is apparent that the fauna of the Blackwood is characteristic of other open estuaries along the south coast. However, many of the species found in these estuaries do extend in numbers northwards, but generally only as far as the Shark Bay and North West Cape region of Western Australia. Such teleosts include the Yellow-eye Mullet, Western Whiting, Australian Herring, Black Bream, Pink Snapper, Skipjack Trevally and Common Blowfish. Thus in this case also, a close parallel can be drawn with the conclusions of the studies of Wilson and Gillett (1974), who regard the North West Cape area as the northern limit of the distribution of gastropod representatives of their Southern Australian Region (Temperate).

In addition to the above species with a wide distribution in the river systems of south-western Australia are those which, probably because of their relatively low tolerance to high temperatures (see e.g. Macey & Potter, 1978), are more restricted in their distribution and have been found in numbers in recent surveys only in the rivers to the south and east of Cape Leeuwin. These include the anadromous parasitic lamprey, *Geotria australis*, which has been caught in both the saline and freshwater regions of various river systems and the Long-nouted Flounder, *Ammotretis rostratus*, which has been taken in several estuaries. Certain freshwater species which are also only found in south coast rivers, include the Black Stripe Minnow, *Brachygalaxias nigrostriatus*, the Trout Minnow, *Galaxias truttaceus*, the Salamander Fish, *Lepidogalaxias salamandroides*, and Balston's Perchlet, *Nannatherina balstoni*.

In contrast to the above groups there are also some species which have a wider distribution around the whole of Australia. One such teleost that is abundant in many estuaries and falls into this category is the Sea Mullet.

While it is not the purpose of this paper to explore at length the degree to which the distribution regions outlined briefly above coincide with those of other workers, a few comparisons are worth recording at this time. For example, while Bennett & Pope's (1953) extensive study on the distribution of intertidal fauna agrees essentially with the pattern described by Wilson & Gillett (1974) and with our preliminary observations, their Dampierian-tropical province is shown as extending around the south-west tip of Western

Australia to the Albany region of the State. From the limited data available to him on fish distributions at the time of his study, Briggs (1974) drew attention to the apparent significance of the Shark Bay region south of the North West Cape as a point which he regarded as separating temperate and tropical faunas. This latter study, and our findings, thus disagree with the line drawn by Whitley (1932) which shows a division of these two categories just south of Geraldton.

SUMMARY AND CONCLUSIONS

There is still a paucity of detailed information on the estuarine teleost component of many Western Australian coastal river systems, particularly those above the North West Cape. Our extensive sampling programme, which was carried out at very regular intervals during the year, has provided, however, detailed information on the movements and biology of many species within the Swan-Avon River System. Such information facilitated the categorisation of some of the fishes of marine origin into groups according to the way in which they use the estuarine component of the river. Thus, these species were separated into those that employed the estuary predominantly either as a nursery area or adult feeding ground, or as an environment that is exploited at various times during the life cycle. A further group was recognised which consisted of 'marine stragglers' that normally remain in oceanic environments. Yet, one of the most interesting findings was that populations of some species constituted another group in which the whole of the life cycle was spent in an estuarine environment. It is hoped that these data, which also facilitate broad distinctions to be made between stenohaline and euryhaline species, will be of value to ichthyological systematists who often only list fishes as having a marine or fresh water distribution. It is also evident that, because of the movement patterns of many species within Western Australian river systems, any sampling programmes aimed at further elucidating zoogeographical patterns in this region should ideally be based on samples taken at different times of the year.

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REFERENCES

- BAIRD, S.F. & GIRARD, C. (1853)—Description of new species of fishes collected by Captains R.B. Marcy and Geo. B. McClellan in Arkansas. *Proc. Acad. nat. Sci. Philad.* 1853: 390-392.
- BAYLY, I.A.E. (1975)—Australian estuaries. *Proc. ecol. Soc. Aust.* 8: 41-66.
- BENNETT, A. (1940)—Tides in the Swan River Estuary. *Trans. Instn Engrs Aust.* 12: 195-198.
- BENNETT, I. & POPE, E.C. (1953)—Intertidal zonation of the exposed rocky shores of Victoria, together with a rearrangement of the biogeographical provinces of temperate Australian shores. *Aust. J. mar. Freshwat. Res.* 4: 105-159.
- BLEEKER, P. (1855)—Over eenige visschen van Van Diemensland. *Verh. K. Akad. Wet.* 1855, 2: 1-30.
- BLACKBURN, M. (1950)—A biological study of the anchovy, *Engraulis australis* (White), in Australian waters. *Aust. J. mar. Freshwat. Res.* 1: 3-84.
- BONNATERRE, J.P. (1788)—*Ichthyologie. Tableau encyclopédique et méthodique des trois règnes de la nature.* Paris.
- BRIGGS, J.C. (1974)—*Marine zoogeography.* New York: McGraw-Hill.
- CASTELNAU, F.L. (1872)—Contribution to the ichthyology of Australia. *Proc. zool. acclim. Soc. Vict.* 1: 29-247.
- CASTELNAU, F.L. (1873)—Contribution to the ichthyology of Australia. *Proc. zool. acclim. Soc. Vict.* 2: 37-158.
- CASTELNAU, F.L. (1875)—Researches on the fishes of Australia. Philadelphia Centenary Exhibition 1876 (Melbourne 1875): Official Record. *Intercolonial Exhibition Essays* no. 2: 1-52.
- CHALMER, P.N., HODGKIN, E.P. & KENDRICK, G.W. (1976)—Benthic faunal changes in a seasonal estuary of south-western Australia. *Rec. West. Aust. Mus.* 4: 383-410.
- COLLETTE, B.B. (1974)—The garfishes (Hemiramphidae) of Australia and New Zealand. *Rec. Aust. Mus.* 29: 11-105.
- CRONIN, L.E. & MANSUETI, A.J. (1971)—The biology of the estuary. Pp. 14-39 in *A symposium on the biological significance of estuaries*; ed. Douglas, P.A. & Stroud, R.H. Washington, D.C.: Sport Fishing Institute.
- CUVIER, G. (1817)—Le règne animal distribué d'après son organisation, pour servir de base à l'histoire naturelle des animaux et d'introduction à l'anatomie comparée. Vol. 2. Paris.
- CUVIER, G. (1818)—Sur les diodons vulgairement orbes épineux. *Mém. Mus. natn. Hist. nat., Paris* 4: 121-138.
- CUVIER, G. & VALENCIENNES, A. (1828-1849)—*Histoire naturelle des poissons.* Paris: Levrault. 22 vols.
- FORSSKÅL, P. (1775)—*Descriptiones animalium avium, amphibiorum, piscium, insectorum, vermium; quae in itinere orientali observavit. Post mortem auctoris edidit Carsten Niebuhr.* Havniae. Möller.

- FREMINVILLE, M. (1813)—Six nouvelles espèces des genres Balistes et Tetrodon. *Bull. Soc. philomath. Paris* 3: 249-253.
- GERVAIS, P. (1848)—Sur les animaux vertébrés de l'Algérie. *Ann. Sci. nat. Paris* (3) 10: 202-208.
- GILL, T.N. (1858)—Prodromus descriptionis familiae gobioidarum generum novorum. *Ann. Lyceum nat. Hist. N.Y.* 7: 16-19.
- GLAUERT, L. (1949)—*Ovalides reticularis*, a fish new to Western Australia. *West. Aust. Nat.* 2: 45.
- GMELIN, J.F. (1788)—*Systema Naturae*. 13 ed. Leiden: Delamoilliere.
- GRANT, E.M. (1975)—*Guide to Fishes*. 3 ed. Brisbane: Queensland Government.
- GRAY, J.E. (1851)—*List of the specimens of fish in the collection of the British Museum. Part 1. Chondropterygii*. London: British Museum (Nat. Hist.).
- GREENWOOD, P.H., ROSEN, D.E., WEITZMAN, S.H. & MEYERS, G.S. (1966)—Phyletic studies of teleostean fishes, with a provisional classification of living forms. *Bull. Am. Mus. nat. Hist.* 131: 339-456.
- GÜNTHER, A. (1859-1870)—*Catalogue of the acanthopterygian fishes in the collection of the British Museum*. London: British Museum (Nat. Hist.).
- GÜNTHER, A. (1864)—Description of a new species of *Callionymus* from Australia. *Ann. Mag. nat. Hist.* (3) 14: 197-198.
- GÜNTHER, A. (1876)—Remarks on fishes, with descriptions of new species in the British Museum, chiefly from southern seas. *Ann. Mag. nat. Hist.* (4) 17: 389-402.
- GÜNTHER, A. (1886)—Notes on *Pachymetopon* and the Australian species of *Pimelepterus*. *Ann. Mag. nat. Hist.* (5) 18: 367-368.
- HAACKE, J.W. (1885)—Ueber eine neue Art uterinaler Brutpflege bei Wirbelthieren. *Zool. Anz.* 8:488-490.
- HODGKIN, E.P. (1974)—Biological aspects of coastal zone development in Western Australia: 1. General aspects. Pp. 93-111 in *The impact of human activities on coastal zones*. Canberra: Australian Government Publishing Service.
- HODGKIN, E.P. & MAJER, K. (1976)—An index to ecological information on estuaries and marine embayments in Western Australia. *Rep. Div. Fish. Oceanogr. CSIRO* no. 70.
- HOESE, D.F. (1973)—The introduction of the gobiid fishes *Acanthogobius flavimanus* and *Tridentiger trigonocephalus* into Australia. *Koolewong* 2: 3-5.
- JACK, P.N. (1977)—Seasonal variations in the water of the Swan River. *Gov. chem. Labs West. Aust.* no. 14.
- JUTSON, J.T. (1934)—The physiography of Western Australia. *Bull. geol. surv. West. Aust.* no. 95 (2 ed.): 1-358.
- KENDRICK, G.W. (1976)—The Avon: faunal and other notes on a dying river in south-western Australia. *West. Aust. Nat.* 13: 97-114.
- KLUNZINGER, C.B. (1879)—Die v. Muller'sche Sammlung australischer Fische in Stuttgart. *Sber. Akad. Wiss. Wien.* 80: 325-340.
- KNER, R. (1865)—Fische. In *Reise der osterreichischen Fregatte "Novara" um die Erde in den Jahren 1857-1859. ... Zoologischer Theil* 2: 110-272.
- KOWARSKY, J. (1973)—Seasonal movement of cobbler along the Swan Estuary. *Aust. mar. Sci. Bull.* no. 44: 9.
- KOWARSKY, J. (1975)—*Strategy and zoogeographic implications of the persistence of the estuarine catfish Cnidoglanis macrocephalus (Val.) (Plotosidae) in Australia*. [Ph.D. Thesis, University of Western Australia.]
- KOWARSKY, J. (1976)—Clarification of the name and distribution of the plotosid catfish *Cnidoglanis macrocephalus*. *Copeia* 1976: 593-594.
- LACEPEDE, B.G.E. (1798-1803)—*Histoire naturelle des poissons*. Paris: Plassen. 5 vols.
- LENANTON, R.C.J. (1970)—*The biology of the commercially fished whiting (Sillago spp.) in Shark Bay, Western Australia*. [M.Sc. Thesis, University of Western Australia.]
- LENANTON, R.C.J. (1974a)—Fish and crustacea of the Western Australian south coast rivers and estuaries. *Fish. Res. Bull. West. Aust.* no. 13.

- LENANTON, R.C.J. (1974b)—The abundance and size composition of trawled juvenile snapper *Chrysophrys unicolor* from Cockburn Sound, Western Australia. *Aust. J. mar. Freshwat. Res.* **25**: 281-285.
- LENANTON, R.C.J. (1977a)—Aspects of the ecology of fish and commercial crustaceans of the Blackwood River Estuary, Western Australia. *Fish. Res. Bull. West. Aust.* no. 19.
- LENANTON, R.C.J. (1977b)—Fishes from the hypersaline waters of the stromatolite zone of Shark Bay, Western Australia. *Copeia* **1977**: 387-390.
- LESSON, R.P. (1830)—Zoologie. In: Duperrey, L.I. *Voyage autour du monde—sur la corvette... "La Coquille" pendant... 1822-25*. Paris: Bertrand.
- LINNAEUS, C. (1758)—*Systema naturae*, 10 ed. Holmiae: Salvii.
- LINNAEUS, C. (1766)—*Systema naturae*, 12 ed. Holmiae: Salvii.
- MACEY, D.J. & POTTER, I.C. (1978)—Lethal temperatures of ammocoetes of the southern hemisphere lamprey, *Geotria australis* Gray. *Environ. Biol. Fishes.* **3**: 241-243.
- MACLEAY, W. (1881)—Descriptive catalogue of the fishes of Australia. Pt.1. *Proc. Linn. Soc. N.S.W.* **5**: 510-629.
- McCULLOCH, A.R. (1911)—*Zoological results of fishing experiments carried out by the F.I.S. "Endeavour" 1909-1910.* **1** (1): 1-87.
- McCULLOCH, A.R. (1912)—Notes on some Western Australian fishes. *Rec. West. Aust. Mus.* **1**: 78-97.
- McCULLOCH, A.R. (1914)—*Zoological results of fishing experiments carried out by the F.I.S. "Endeavour": 1909-1910.* **2** (3): 77-165.
- MEES, G.F. (1977)—The status of *Gambusia affinis* (Baird & Girard) in south-western Australia. *Rec. West. Aust. Mus.* **6**: 27-31.
- MEYER, F.A. (1793)—*Systematisch-summarische Uebersicht der neuesten zoologischen Entdeckungen in Neuholland und Africa*. Leipzig: Dykirchen.
- MITCHELL, T.L. (1839)—*Three expeditions into the interior of eastern Australia... 2 ed.* London: Boone.
- MORRISSY, N.M. (1970)—Murray cod, *Maccullochella macquariensis*, in Western Australia. *West. Aust. Nat.* **11**: 130-135.
- MORRISSY, N.M. (1972)—An investigation into the status of introduced trout (*Salmo* spp.) in Western Australia. *Rep. Dept. Fish. Fauna West. Aust.* no. 10: 1-45.
- MÜLLER, J. & HENLE, F.G.J. (1841)—*Systematische Beschreibung der Plagiostomen*. Berlin: Verlag.
- MUTTON, L.A. (1973)—*Studies on the osmoregulation of the inland-water goby, Lizagobius olorum from south-western Australia.* [M.Sc. Thesis, University of Western Australia.]
- MUNRO, I.S.R. (1949)—Revision of Australian silver breams *Mylio* and *Rhabdosargus*. *Mem. Qd Mus.* **12**: 182-223.
- MUNRO, I.S.R. (1956)—Handbook of Australian fishes. No. 6. *Fish. Newsl.* **25** (12): 25-28.
- NICHOLS, J.T. (1920)—A key to the species of *Trachurus*. *Bull. Am. Mus. nat. Hist.* **42**: 477-481.
- OGILBY, J.D. (1897)—New genera and species of Australian fishes. *Proc. Linn. Soc. N.S.W.* **22**: 62-65.
- OGILBY, J.D. (1899)—Contribution to Australian ichthyology. *Proc. Linn. Soc. N.S.W.* **24**: 154-186.
- OSBECK, P. (1765)—*Reise nach Ostindien und China, etc. Deutsche uebersetzung von. J.G. Georgius*. Rostock.
- PENN, J.W. (1977)—Trawl caught fish and crustaceans from Cockburn Sound. *Rep. Fish. Wildl. West. Aust.* no. 20.
- PETERS, W.C.H. (1865)—Ueber einige neue Seugeithiere, Amphibiän und Fische. *Mber. dt. Akad. Wiss. Berl.* **1864**: 381-399.
- POLLARD, D.A. (1976)—Estuaries must be protected. *Aust. Fish.* **36** (6): 6-10.
- POTTER, I.C. & STRAHAN, R. (1968)—The taxonomy of the lampreys *Geotria* and *Mordacia* and their distribution in Australia. *Proc. Linn. Soc. London.* **179**: 229-240.

- QUOY, J.R.C. & GAIMARD, J.P. (1824)—Zoologie. In: *Voyage autour du monde exécuté sur les corvettes de S.M. "L'Uranie" et "La Physicienne" pendant les années... 1817-20... 2*. Paris: Tastu.
- RAMSAY, E.P. & OGILBY, J.D. (1886)—Descriptions of some new Australian fishes. *Proc. Linn. Soc. N.S.W.* (2) 1: 4-7.
- REGAN, C.T. (1903)—On the classification of the fishes of the suborder Plectognathi, with notes and descriptions of new species from specimens in the British Museum collection. *Proc. zool. Soc. Lond.* 1902 (2): 284-303.
- REGAN, C.T. (1907)—Description of *Velifer hypselopterus* and a new species of *Velifer*. *Proc. zool. Soc. Lond.* 1907 (2): 633-634.
- REND AHL, H. (1921)—Results of Dr E. Mjöberg's Swedish Scientific Expeditions to Australia, 1910-1913. *K. svenska Vetensk Akad. Handl.* 61 (9): 1-24.
- RICHARDSON, J. (1836)—Fishes. In *Fauna Boreali-Americana*, Part 3. London: Bentley.
- RICHARDSON, J. (1839)—Description of fishes collected at Port Arthur in Van Diemen's Land. *Proc. zool. Soc. Lond.* 1839 (7): 95-100.
- RICHARDSON, J. (1840)—On some new species of fishes from Australia. *Proc. zool. Soc. Lond.* 1840 (8) 25-30.
- RICHARDSON, J. (1841)—On some new species of fishes from Australia. *Proc. zool. Soc. Lond.* 1841 (9): 21-22.
- RICHARDSON, J. (1843)—Contributions to the ichthyology of Australia. *Ann. Mag. nat. Hist.* 11: 169-182.
- RICHARDSON, J. (1844-48)—*Ichthyology of the voyage of H.M.S. Erebus and Terror*. London: Newman.
- RICHARDSON, J. (1849)—Description of Australian fish. *Trans. zool. Soc. Lond.* 3: 69-131.
- RICHARDSON, J. (1850)—Notices of Australian fish. *Proc. zool. Soc. Lond.* 1850 (18): 58-77.
- ROCHFORD, D.J. (1951)—Studies in Australian estuarine hydrology. 1. Introductory and comparative features. *Aust. J. mar. Freshwat. Res.* 2: 1-116.
- RÜPPELL, E. (1835)—*Neue Wirbelthiere zu der Fauna von Abyssinien gehörig*. 2 vols. Frankfurt.
- SAUVAGE, H.E. (1880)—Description des gobioides nouveaux ou peu connus de la collection du Muséum d'Histoire Naturelle. *Bull. Soc. philomath. Paris* (7) 4: 40-58.
- SAUVAGE, H.E. (1883)—Descriptions de quelques poissons de la collection du Muséum d'Histoire Naturelle. *Bull. Soc. philomath. Paris* (7) 7: 156-161.
- SCOTT, T.D., GLOVER, C.J.M. & SOUTHCOFF, R.V. (1974)—*The marine and freshwater fishes of South Australia*. 2 ed. Adelaide: Government Printer.
- SEDDON, G. (1972)—*A sense of place*. Perth: University of Western Australia Press.
- SERVENTY, D.L. (1955)—The fauna of the Swan River Estuary. Pp. 70-77 in *Report by sub-committee on pollution of the Swan River Reference Committee*. Perth: Government Printer.
- SHAW, G. (1798)—*The naturalist's miscellany*. Vol. 9. London: Nodder.
- SPENCER, R.S. (1956)—Studies in Australian estuarine hydrology. II. The Swan River. *Aust. J. mar. Freshwat. Res.* 7: 193-253.
- STEINDACHNER, F. (1884) Beiträge zur Kenntniss der Fische Australiens. *Sber. Akad. Wiss. Wien* 88: 1065-1108.
- THOMSON, J.M. (1950)—The effect of a period of increased legal minimum length of sea mullet in Western Australia. *Aust. J. mar. Freshwat. Res.* 1: 199-220.
- THOMSON, J.M. (1951)—Growth and habits of the sea mullet *Mugil dobula* Günther in Western Australia. *Aust. J. mar. Freshwat. Res.* 2: 193-225.
- THOMSON, J.M. (1954)—The organs of feeding and the food of some Australian mullet. *Aust. J. mar. Freshwat. Res.* 5: 464-485.
- THOMSON, J.M. (1955)—The movements and migration of mullet (*Mugil cephalus*). *Aust. J. mar. Freshwat. Res.* 6: 328-347.
- THOMSON, J.M. (1957a)—Biological studies of economic significance of the yellow-eye mullet, *Aldrichetta forsteri* (Cuvier & Valenciennes) (Mugilidae). *Aust. J. mar. Freshwat. Res.* 8: 1-13.
- THOMSON, J.M. (1957b)—Interpretation of the scales of the yellow-eye mullet *Aldrichetta forsteri* (Cuvier & Valenciennes) (Mugilidae). *Aust. J. mar. Freshwat. Res.* 8: 14-28.

- THOMSON, J.M. (1957c)–The food of Western Australian estuarine fish. *Fish. Bull. West. Aust.* no. 7: 1-13.
- THOMSON, J.M. (1957d)–The size at maturity and spawning times of some Western Australian estuarine fishes. *Fish. Bull. West. Aust.* no. 8: 1-8.
- THOMSON, J.M. (1957e)–The penetration of estuarine fish into freshwater in the Albert River. *Proc. R. Soc. Qd* 68: 17-20.
- THOMSON, J.M. (1966)–The grey mullets. *Oceanogr. mar. Biol.* 4: 301-335.
- VARI, R.P. (1978)–The terapon perches (Percoidei, Teraponidae). A cladistic analysis and taxonomic revision. *Bull. Am. Mus. nat. Hist.* 159: 175-340.
- WAITE, E.R. (1905)–Notes on fishes from Western Australia. No. 3. *Rec. Aust. Mus.* 6: 55-82.
- WENG, H. T-C. (1970)–*The black bream, Acanthopagrus butcheri (Munro), its life history and fishery in South Australia.* [M.Sc. Thesis, University of Adelaide.]
- WHITE, J. (1790)–*Journal of a voyage to New South Wales.* London: Debrett.
- WHITLEY, G.P. (1930)–Ichthyological miscellanea. *Mem. Qd Mus.* 10: 8-31.
- WHITLEY, G.P. (1931)–Studies in ichthyology, No. 5. *Rec. Aust. Mus.* 18: 138-160.
- WHITLEY, G.P. (1932)–Marine zoogeographical regions of Australasia. *Aust. Nat.* 8: 166-167.
- WHITLEY, G.P. (1944)–New sharks and fishes from Western Australia. *Aust. Zool.* 10: 252-273.
- WHITLEY, G.P. (1951)–New fish names and records. *Proc. R. zool. Soc. N.S.W.* 1949-50: 61-68.
- WILSON, B.R. (1964)–*Breeding biology of some Western Australian marine and estuarine Mytilidae (Mollusca: Bivalvia).* [Ph.D. Thesis Univ. of Western Australia.]
- WILSON, B.R. (1968)–Survival and reproduction of the mussel *Xenostrobus securis* (Lam.) (Mollusca: Bivalvia: Mytilidae) in a Western Australian estuary. Part 1. Salinity tolerance. *J. nat. Hist.* 2: 307-328.
- WILSON, B.R. & GILLETT, K. (1974)–*Australian shells*, Rev. ed. Sydney: Reed.